Question 1 (25 marks)

(a) Discuss the advantages of the following concepts in data communication:

(i) Full duplex transmission [2 marks]

(ii) Encapsulation process [2 marks]

(iii) Bit stuffing [2 marks]

(b) Figure Q1.1 shows the transmission of Packet 1 with the data-link layer applying the Stop-and-Wait protocol. Packet 1 and Packet 2 are respectively transmitted when Frame 1 and Frame 2 are received successfully.

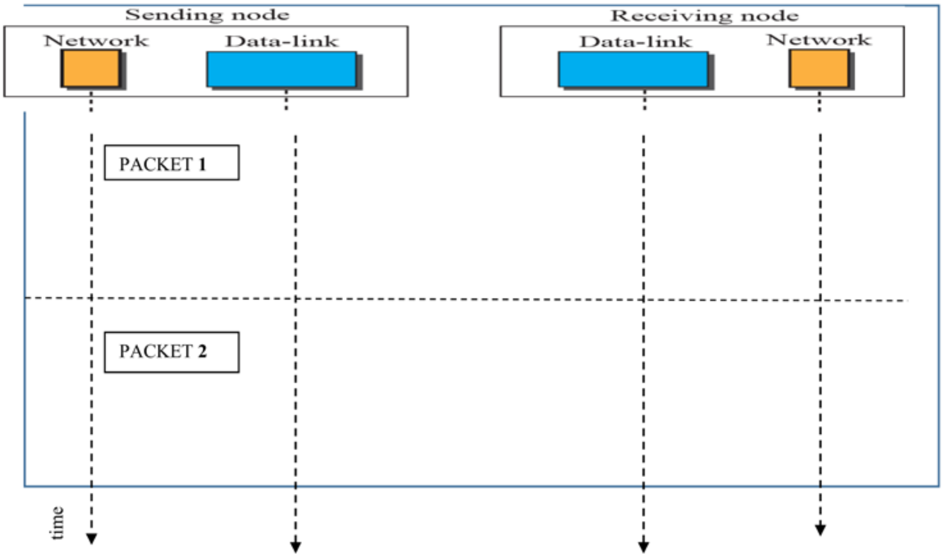

Figure Q1.1

Redraw Figure Q1.1 and show the flow diagram for the following scenarios:

(i) Frame 1 is sent and lost. [1 mark]
(ii) Frame 1 is resent and successfully acknowledged. [1 mark]
(iii) Frame 2 is received and acknowledged, but the acknowledgement is lost. [1 mark]
(iv) Frame 2 is resent and acknowledged. [1 mark]
(v) Discuss TWO reasons why frames are lost during transmission. [2 marks]

(c) One of the most common protocols for point-to-point access is the Point-to-Point Protocol (PPP).

(i) Discuss TWO reasons why frames are lost during transmission. [3 marks]

(ii) Briefly describe the TWO features within the PPP protocol that makes this protocol secure. [5 marks]

(d) Describe the advantages of the hybrid topology shown in Figure Q1.2. [5 marks]

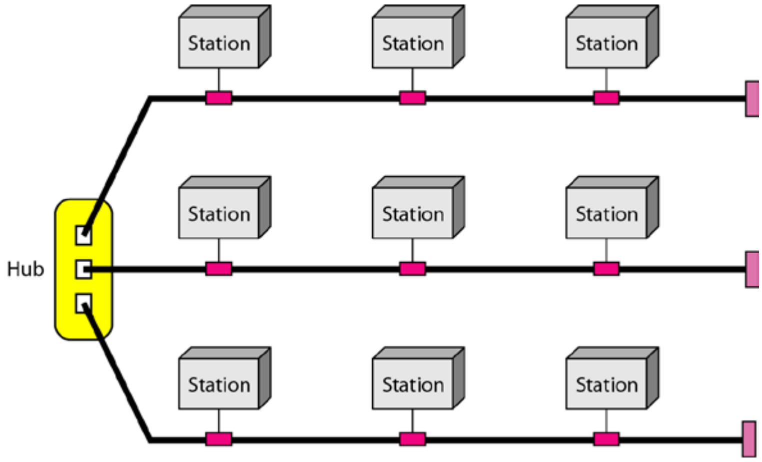

Figure Q1.2

Question 2 (25 marks)

(a) (i) Define random access and list three protocols in this category. [3 marks]

(ii) Briefly explain why the collision detection mechanism can be deployed on wired networks but not on a wireless network. What mechanism is used to address collision in a random access wireless networks? [5 marks]

(iii) In recent years, the IEEE 802.11 WiFi standards have evolved to achieve higher throughputs in the Gigabit range. List four related physical layer improvements made. [3 marks]

(b) A CSMA/CD network with four stations is shown in Figure Q2.1. The data rate is 10 Mbps, the distance between stations A and C is 2000 m, the distance between stations C and D is 500 m, and the signal propagation speed is 2×10^8 m/s.

Figure Q2.1

Station A start sending a frame at time $t_1 = 0$; station C starts sending a frame at $t_2 = 2$ µs. Determine the following:

(i) Minimum frame size required to guarantee collision detection by all stations. [2 marks]

(ii) The time when station C detects the collision. [2 marks]

(iii) The time when station A detects the collision. [2 marks]

(iv) The number of bits station A has sent before detecting the collision. [1 mark]

(v) The number of bits station C has sent before detecting the collision. [1 mark]

(c) (i) Name the type of Ethernet shown in Figure Q2.2. [1 mark]

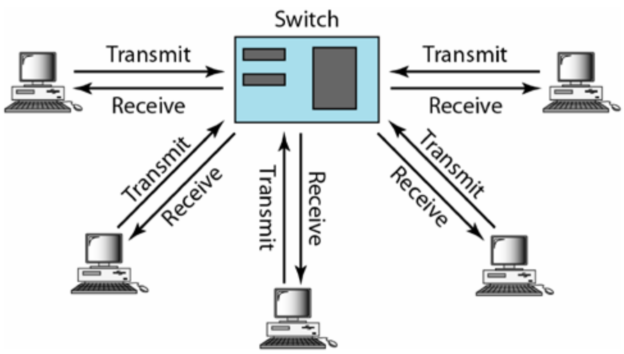

Figure Q2.2

(ii) Is there a need to use CSMA/CD in the network shown in Figure Q2.2? Justify your answer. [2 marks]

(iii) Obtain the hexadecimal equivalent of the following Ethernet address. [3 marks]

00111010 00010001 01010101 00011000 10101010 00001011

Question 3 (25 marks)

(a) The Internet Protocol (IP) is an important network layer protocol that enables host-to-host delivery and routing.

(i) Is IP a reliable or unreliable protocol? Justify your answer. [3 marks]

(ii) Is IP a connection-oriented or connectionless protocol? Justify your answer. [2 marks]

(iii) How many bits are there in an IPv4 (IP Version 4) address? [1 mark]

(iv) IPv6 (IP Version 6) is the successor of IPv4. How many bits are used in IPv6 addressing? [1 mark]

(b) A classless address is given as 125.170.168.84/26.

(i) How many host addresses are available in the network? [1 mark]

(ii) Determine the first address in the network. Show your working. [3 marks]

(iii) Determine the last address in the network. Show your working. [3 marks]

(c) A company is assigned the IP address of 74.0.10.0/25. Design an IP addressing scheme with subnetting that can accommodate 6 subnets with 15 usable hosts in each subnet.

(i) Determine the number of bits that must be borrowed from the Host ID in order to accommodate the 6 subnets. [1 mark]

(ii) What is the number of bits that must be reserved to accommodate the 15 hosts? [1 mark]

(iii) What is the subnet mask used? [2 marks]

(d) Sending a 5000-byte datagram with a 20-byte IP header into a link with an MTU (Maximum Transfer Unit) of 500 bytes requires fragmentation. How many fragments are generated? What is the size of each fragment? Specify the fragmentation offset and flag for each fragment.

[7 marks]

Question 4 (25 marks)

(a) Assume a Transmission Control Protocol (TCP) client expects to receive byte 2021, but it receives a segment with sequence number 2011. What is the reaction of the TCP client to this event? Explain the reason. [5 marks]

(b) Figure Q4 shows a dump of a TCP header in hexadecimal format:

06780AF0 00001B53 00000000 500203DF 00000000

Figure Q4

Answer the following questions:

(i) What is the source port number in decimal? [1 mark]

(ii) What is the destination port number in decimal? [1 mark]

(iii) What is the acknowledgement number in decimal? [1 mark]

(iv) What is the sequence number in decimal? [1 mark]

(v) What is the length of the header in decimal? [1 mark]

(vi) What is the type of the segment? [1 mark]

(vii) What is the window size in decimal? [1 mark]

(c) Assume we need to design a Selective-Repeat sliding-window protocol for a network in which the bandwidth is 10Gbps and the average distance between the sender and receiver is 10000 km. Assume the average packet size is 1000,000 bits and the propagation speed in the media is 2×108 m. Find the maximum size of the send and receive windows, the number of bits in the sequence number field (m), and an appropriate time-out value for the timer. [7 marks]

(d) A TCP connection is using a window size of 10000 bytes, and the previous acknowledgement number was 22001. It receives a segment with acknowledgement number 24001 and window size advertisement of 12000. Draw a diagram to show the situation of the window before and after the transmission. [6 marks]